DARPA Programs

DR. FISH: Thanks, Jose.

I am one of those 150 people with no job, connected by the travel agents.

I am going to talk a little bit about some of the programs at DARPA, not all of them. I would like to talk a little bit about the programs related to robotics, but I want to be real careful today because I really don't want to distract you. This is not about DARPA, this is about you guys.

So, let me tell you a little bit about some of the things that are going on, but don't feel like you are supposed to be grabbing this stuff and figuring out how to make it work for the Challenge. What we are really looking for is to show you a little bit about what's going on.

If it's something that gets your juices flowing, you will have some contacts, but we want you to be doing your thing, not coming to us with some more stuff that's like what we are already doing.

Next slide, please.

The first one I am going to talk about is RHex. It is part of the biologically inspired programs that are being done at DARPA. It is being run by Dr. Alan Rudolph.

Next slide, please.

I am going to try to do this myself. There are a couple of movies here. RHex stands for Robotic Hexapod, so it's six-legged. Let's start the movie. I am going to point to it and you start it, that one, and let's go ahead and start this one, too. Just click them both to start.

This vehicle is about this big, and it has got six legs, and each of the legs is flexible. So, this robot is looking at some new mobility techniques. These legs are not just sticks. They actually have some spring to them and capitalize on some of the things that we use in our legs with muscles, so it is a combination structural-muscular type of leg system.

This vehicle is not autonomous, it is just RC, like a regular toy. It is meant to explore some of these new methods of mobility, but it is very interesting in that sense.

Dr. Rudolph is also looking at robotic lobsters and in the future would like to look at some additional things, things that jump. I have no idea what this was. I got these slides yesterday. This is looking at climbing things, things that can go up walls and maybe up on the roof, and you can let your imagination go as to how we might use those things.

Let's go ahead and get the next slide.

This is a general area that we are interested in from the biologically inspired stuff. One is visual odometry and optical flow. This might be a technique that someone would want to use in the Challenge, tracking motion, your own motion, by looking at objects just the same way we do.

As we move around, for instance, if I were to walk up this aisle, I would notice that the pillars are moving by in a certain way, and that is processed in our brains to tell us something about where we are. So, that is something that we are looking at trying to provide capability in robotic systems for. It gives you improved dynamic motion, but another area is probe reception, or touch and feel.

A lot of the times when we think about robots, we think about what they see, maybe what they hear, but there is a lot of good research going on looking at touch and feel, how different animals use antenna to feel their way around, and that is an area that we are looking at also at DARPA.

Next slide, please.

The next one is being run by Dr. Doug Gage. You will see some more about him in a minute.

Next slide.

These are areas having to do with intervention. Again, some of this stuff is going to apply to the Challenge, some of it is not. This is one where intervention, how users get involved and help robots out, doesn't apply because we don't want you to get involved with the robot here.

What we do want you to potentially deal with is the perception if the robot is going to have to move around and do things by itself. Learning and adaptation may be great if your vehicle learns as it goes along, which may be a really good way to do well.

You may actually do some learning at your own home before you take it out or go take it out in some area of the desert before we get started, teach your system how to do things, but once it gets started at the beginning, there is no more interaction type learning. It has got to learn on its own.

Behaviors and architecture. This has to do more with multiple robots, so maybe not so applicable here, and interaction again has more to do with humans.

Let's go ahead and go to the next slide.

Perception is again an area that is important. This is a movie clip. We will go ahead and start this one. It has to do with how you can use single cameras to map interior spaces, and this kind of technique can also be used for exterior movement, it is just a lot harder because it gets pretty far away and you have to try and figure out where it is. But it might be a technique that is very useful for the Grand Challenge.

Next slide, please.

This is just the vehicle as it was doing this kind of mapping exercise, so this was obviously in a cave. This is actually a mining application.

Let's go ahead and go to the next slide.

I am going to not spend a long time on this one because you are not supposed to interact with humans while you are on the course. It is important to know, though, that DARPA is doing a little work having to do with remote operations of machines. In this particular case, we are doing it with NASA where there is an operator up in Virginia and he is operating this humanoid robot down in Houston.

Next slide, please.

These are some contacts. So, if you are seeing anything that you like or you are interested in some of these areas, and I believe all of this information is going to be provided to you, I know it is going to be on the web site available to you, so these are just some software algorithms that have been worked by DARPA at various places.

If you are interested in any of these particular areas as you put together your teams or put together your project, these are places you can go for those resources.

I am not even going to bother to let you read all of it right now because it will be available to you after we are done, and there is another one after this.

Go ahead, the next slide.

Some more stuff. Visual tracking software, continuously timed varying behaviors, and generic robot languages. So, there is a lot of work that has been done. This is public information type stuff, so you have some access to it should you decide that that is an avenue you want to take.

Next slide, please.

Another program, distributed robotics, being run by Elana Ethridge also at DARPA.

Next slide.

These are very small robots. The focus here is on how do you use lots of small robots to do some things together. These are just pictures of these things. I don't want to go into too much depth on it because none of these robots that are this small are going to be able to go 350 kilometers, that I know of. Again, if you have got a small robot this size you think that can make it, bring it on. We would love to see a small robot go that far.

Next slide.

Software for distributed robotics. This one is linked with the other program. This is more the software side whereas the other one is looking at how you build small robots to survive their sort of environment. Again, Doug Gage is the program manager, and I am giving you contacts for all of these as we go along.

Next slide.

Software for distributive robotics. Again, it has to do with multiple robots, so it may or may not be applicable for the Challenge, but what is important is that it is looking at a few things having to do with how robots communicate with each other.

Again, robot-human interface is of interest to us.

I guess if any of these things are of interest to you, these sort of go beyond what the Challenge is.

Next slide.

Now, I am going to talk about two programs that I happen to be the program manager of. This is me. The first one is called Preceptor.

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This is a program that has been going for about two years. We have had three teams with complementary approaches. This program uses a Honda ATV as the vehicle, so the purpose of this was to stay away from trying to build a unique robot. We wanted all the teams using the same ground mobility platform, and we are focusing on how they deal with autonomy, although not total autonomy as in your case, but having autonomy sometimes and then getting a human involved when you run into big trouble.

We did four field experiments last year. One of them happened to be in Yuma, so it is going to be in the same country that you could be operating in. We also did some experiments up in Virginia. We did some experiments in Northern California, just a little north of Yosemite, and also at Fort Pope, which is down in the swamps of Louisiana.

We are working on the last phase of this now, and these are just some pictures of the different sorts of approaches that these guys have taken.

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A little information about what they are using. Sensor-wise, at least, we have some Ladars. All the teams are using Ladar. This is laser radar. The reason that they are using it, it is really, from what we have observed at least, the dominant sensor right now.

You can use it day and night, and the next slide I will show you is a blow-up of this guy. We are doing a lot of night testing in this program for obvious reasons for the military.

But we are also looking at some passive sensors. In this case, MWIR stands for mid-wave infrared. We also have some long-wave infrared stuff and also some day camera stereo. So, we are working a lot of different types of sensors. In fact, the stereo systems that we have got here are really starting to look pretty good, and I think they could be very promising for the types of approaches that you are looking at.

Radar. We have some radar sensors in here that we are looking at, and they have also been productive at finding some things like wire, that both of the other systems seemed to have some trouble with.

And we are looking at new techniques with 2D cameras for doing 3D imaging that is very similar to this optical flow stuff I described earlier, where you have got a camera and you are watching stuff go by and make sense of what that means for you in your own position.

Next slide.

Again, this is a blow-up just to emphasize that we are doing testing in day and night, so we are looking for solutions that work in both regimes. That is a little robot down there, and this one, that was out in Yuma.

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Another thing that we are looking at, and you will have to speak with the Rules Committee, I don't know exactly whether this is legal or not, but it certainly was legal in our program. That was one of the teams actually -- this is their ATV down here -- they were looking at putting one of the sensors for their vehicle on a flying platform.

So, they are using this helicopter up here with sensors mounted on-board to look down on the terrain and see some things that they can't see because they are so low. They successfully did this last year. We are working on improving it. Clearly, it's a good technique.

Militarily, we have got to figure out how to do this without giving away the position of this guy, but this is an area that DARPA is working pretty hard.

Next slide.

Using overhead data. Again, this is something I think if you have looked at the rules, you are allowed to use some overhead imagery that is commercially available. We have looked very hard at this problem in our program, and we find that it is very useful certainly for path planning.

The most common thing is you get a good picture of what is going on out there, use it just like people do, and say, well, let me avoid the bad ditches or ugly rocky areas and go just where it looks good. We are very good at doing that already, and I think this is an area where Challenge participants are also going to want to use it.

I am also interested in re-planning on the fly because sometimes you don't end up going where the plan says and you need to be able to re-plan. That means you have got to have this kind of information available down on your vehicle if you are not going to do communication back to a human, which is your particular case.

Maybe more important is -- and I am trying to emphasize this with the guys over the next year -- is trying to use this information to change the way you look at things. In other words, if you know that you have moved off of the trail, and you are into a small rocky area, set your sensors up for looking at small rocky areas.

If you have moved into a wooded area, you potentially need to change the way you are looking at things, so that you understand that a trunk is a trunk, and it is not now the side of a building or some other thing, and we are not really doing that very well yet. So, that is an area that we are pushing on pretty hard.

These are just some examples of doing some planning. This one happens to be in Louisiana, and the planning here is very important because this is a trail, and if we tell the guy to start from here and go get inside this fort, there is a cliff right here along the side of the trail that this kind of overhead data can detect.

In this case, it saves the vehicle by keeping the vehicle from trying to go over this cliff, and instead takes the longer route and successfully gets there.

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The next program I am going to talk about is the vehicle program. It is called Unmanned Ground Combat Vehicle, and it is really tailored on the same idea that the Air Force and the Navy are using to look at combat aircraft without people on-board.

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The emphasis in this program, again, it is only a couple of years old, is to look at design of vehicles from scratch knowing that people are not on-board. We already have done a number of conversions of vehicles that are designed for people, both tanks, trucks, humvees. Those work just fine, but you give up something when you take a vehicle that was designed for something else.

In this case, we need to maximize some new performance in order to figure out whether this is worth doing. So, the performance that we are looking at is endurance of 14 days and 450 kilometers.

The 450 kilometers is somewhat relevant here, without re-supply. The 14 days is relevant because in a military application, you are not moving all the time, and when you are not moving, you probably have some stuff on, and that consumes energy, so that ends up being a big driver for our design here.

Mobility is obviously important. It is important because you want to be able to go places that other vehicles can't go, but it is also important because if the perception system messes up and does not see the boulder or the drop-off, you would like to be building a vehicle that can take the damage that that kind of activity is going to induce. You want to be able to do it at slow speed and potentially at moderate speed.

Finally, we put this payload fraction in here because an important part of this is being able to take these vehicles, put them on aircraft and get them overseas.

We know we can do these two things if we build a really large vehicle. So, this is the metric that keeps the vehicle from becoming very large.

We have had a lot of different design concepts for this. I should have put a slide in here for all of them, and I didn't even think about it until just now, but I will make sure that we post on my web site all the different designs that we have looked at in this program.

There are some pretty interesting ones, but only two of them have survived to the point where we are actually building full prototypes, and I will show you some pictures of them in just a minute.

These are the teams that are working. This vehicle is about seven tons, and this vehicle is a tenth of that. So, we are looking at two different scales because there are different applications for the military. It is not clear that the answer that you want to use in the near term for a seven-ton vehicle is the same answer that you want to use down at this size.

Remember that this is a program that is trying to bridge that gap between far and near. Because of the time scale of this program, we couldn't go pick the six-legged thing with the arms jumping all over everywhere because it is not ready to be built this big.

Next slide.

This is an internal view of the big guy. It has a payload bay in the center. Both of these vehicles it just so happens are capable of inversion. They are designed to tumble over and continue running upside down, and that, of course, brings on a lot of very difficult design problems.

One is what do you do with the payloads. If you are upside down, you need to be able to poke your mission system up whether it's a sensor or a weapon system or whatever, and in this case, the team has gone to a rotating payload bay. So if the vehicle flips over on its back, there is a hole in the bottom, it rotates the payload around and pokes it out what used to be the bottom and keeps going.

The other team working with the smaller vehicle uses arms that can rotate in one plane all the way around, and this vehicle is very interesting in the sense that it starts to exhibit some real climbing and leg-like behavior, although it can operate like a regular wheeled vehicle.

Both of these vehicles can squat themselves down really low, which is nice for us because it makes them hard to see, and there are some general technology advancements that have gone on here, that even if the military said I don't want this exact vehicle, there is a whole bunch of pieces in here that may be of interest.

That same philosophy, by the way, is going to be important for you all. When we watch what you do as a part of your activity, even if the vehicle you come up with wins or doesn't win, but has something really neat in it, that is the point that Dr. Tether was making, come in to approach us about some subsystems that can be very important.

Next slide, please.

The little vehicle just rolled out less than a month ago, so it is out. This is an example of the sorts of things you can do with this behavior, having arms that can rotate 360 degrees. In this case, this is a pose that is preparing for climbing over a 1-meter obstacle.

You could not climb over a 1-meter obstacle with a typical vehicle with tire sizes like this. This is a regular ATV tire on here.

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The other vehicle also just rolled out even a shorter time ago. This one is up in Pittsburgh, so it was snowing when they did it, and it's a skid steer vehicle, and it does not climb, but it does have the ability to rotate the suspension system all the way up over the top, so that if it flips over on its back, it can operate upside down.

It has a very nice suspension system and is also very heavy duty. These guys, the energy involved in a vehicle of this size smacking into stuff is very serious, and this vehicle has been designed from the ground up with a lot of analysis on smacking into trees and walls at significant speed.

Next slide.

Let me go ahead and play this movie. This is an early prototype.

[Movie shown.]

So, I hope that sort of gets your juices flowing. It always does mine.

These guys have a number of design constraints that they are going after and many of them are way beyond what you need to do with regards to mobility.

Next slide, please.

Another short movie. This is a competition, rock-climbing vehicle.

There is more than one way to skin a cat here, and there are many more than these. We are hoping that you guys are going to come up with some stuff we have never seen before.

The one benefit that the other vehicle had was that because it had six wheels, it did not have to have a smart driver on-board. There are lots of ways to do this. We are looking for all kinds of different ones.

Let me go to the last slide.

There is a lot going on at DARPA. The purpose of the brief was to show you some of that stuff. There is a lot more that obviously needs to be done. We can't do the DARPA Challenge today, and that is why the Challenge was started.

We are pursuing many different means to get where we need to go with this military stuff. The DARPA Challenge is a critical piece of that. I hope that this stuff has been helpful to you. You have gotten some contacts from the slides. Again, we will post it. Grab a DARPA PM. If you don't find me, grab one of the other ones.

If there are some things that are going on here that you think could be helpful, we will try to be helpful. Finally, best of luck in pursuing your own special approaches.

I hope to see lots of videotape like the kind that you saw today a year from now or a year and a half from now when you guys are all successful or moderately successful at the very least and doing some things that we can't do.

Thank you very much.

[Applause.]

COL NEGRON: I will tell you that is pretty exciting stuff here. Let me clarify a few points because I got those questions last night.

First of all, our vehicle will not carry a payload, will not bang into other vehicles, and we will not use UAVs or OAVs out there for sensing. Okay? So, it is really moving from point A to point B.

So, I want to make sure that is clear. I know I got a lot of questions last night about hitting other vehicles out there, even jamming the other vehicles. That is not the purpose of the Challenge.